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Using capstones to develop research skills and graduate capabilities: A case study from physiology

Brianna L. Julien PhD
La Trobe University, B.Julien@latrobe.edu.au

Louise Lexis PhD
La Trobe University, L.Lexis@latrobe.edu.au

Johannes Schuijers PhD
La Trobe University, J.Schuijers@latrobe.edu.au

Tom Samiric PhD
La Trobe University, T.Samiric@latrobe.edu.au

Stuart McDonald PhD
La Trobe University, Stuart.McDonald@latrobe.edu.au

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Abstract
In 2011, the Department of Human Biosciences introduced two physiology capstone subjects as part of the Design for Learning Project at La Trobe University. Consistent with the project, the aims of these subjects were to provide an effective culmination point for the Bachelor of Health Science course and to offer students orientation to opportunities for further study, employment and career development. The aim of this paper is to provide an overview of the skills-related assessment tasks of the newly introduced capstone program and an evaluation of the capstone program based on student performance and feedback scores in conjunction with staff perceptions. The skills-related assessment tasks were designed to facilitate the development of research skills and graduate capabilities such as writing, speaking, creative problem-solving, inquiry/research and team work. Student performance determined by mean scores on the skills-based assessment tasks ranged from A to C. Final grades were significantly higher ($p < 0.01$) in 2011 when compared with final grades in 2010 and 2009. Students reported that the skills-based assessments contributed to their learning and skill development and satisfaction level was high. Staff noted a higher degree of student-centred learning, a vastly increased workload and a greater need for infrastructure services and support staff. Universities and departments should therefore consider staff and resource requirements when implementing curriculum that has a student-centred approach. In conclusion, the revised curriculum successfully promoted the development of research skills and graduate capabilities, thereby leading to work-readiness and/or entry to graduate studies in the Health and Biological Sciences.

Keywords
Capstone, student-centred learning, graduate capabilities, research skills

Cover Page Footnote
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Introduction

In 2011, the Department of Human Biosciences introduced two final year physiology capstone subjects as a result of participation in the Design for Learning Project at La Trobe University. Various studies have indicated that well-designed capstone subjects provide authentic experiences, collaboration and integration of knowledge across the curriculum (Shoaf 2000, FitzPatrick 2004). Indeed, FitzPatrick (2004) showed improved skills and performance of second-year students following the introduction of a capstone-like subject in human physiology. In this study, the sports medicine and biology students were required to carry out self-designed experiments with human subjects, collect data, conduct data analysis, develop skills in scientific communication through written and oral reports and develop skills in group collaboration and teamwork (FitzPatrick 2004). In support of these findings, Hiebert (2007) suggests that student-centred learning is the most appropriate tool to foster learning of simple experimental design. Furthermore, Robbins, Kinney and Kart (2008) developed a health sciences capstone subject where each student designed and conducted their own research project and created a poster and a presentation within a team. The findings of this study showed that students demonstrated a significant increase in their knowledge, as well as perceptions of their research skills (Robbins, Kinney & Kart 2008). Taken together, these findings indicate that well-designed capstone subjects which actively engage science students in all phases of the scientific method will thereby foster learning and the development of research skills. Further, it is clear that student-centred learning is an essential aspect of skill development in these capstone subjects.

Student-centred learning is an element of the constructivist theory of learning which takes place as the student actively participates, interprets, processes and constructs new knowledge (Anderson & Elloumi 2004, Biggs & Tang 2011). With this style of learning, students are required to question, speculate and generate solutions, and this ultimately encourages the use of higher order cognitive processes (Biggs & Tang 2011). Furthermore, the nature of student-centred learning allows greater choice over what is studied, as well as the pace and style of learning (Gibbs 1992). Biggs and Tang (2011) emphasise that teaching methods associated with student-centred learning should focus on what the student does, rather than the teacher. In agreement, Weimer (2002) indicates that staff must actively set out to shift the balance of classroom power from teacher to student in order to foster student-centred learning. Weimer (2002) suggests that this can be achieved if staff members become facilitators and the design of assessments ensure that the responsibility for learning is placed onto the student.

Prior to 2011, the Department of Human Biosciences at La Trobe University offered two final year advanced human physiology subjects. The focus of these subjects was on the delivery of physiology content in lectures and reinforcement of lecture content in practical classes. Assessment was heavily weighted towards the final exam which was worth 70% of the subject grade and the remaining 30% was derived from laboratory reports. Although students typically provided very positive feedback on these subjects, it was clear that much scope existed to increase the amount of student-centred learning, as well as the development of research skills and La Trobe University graduate capabilities: writing, speaking, creative problem-solving, inquiry/research and team work. These graduate capabilities are consistent with those indicated as valuable skills for science graduates undertaking careers in health-related fields (Blake 2010). Typically, advanced physiology students would undertake further study on completion of their degree. Common

pathways include Honours in human biosciences leading onto postgraduate research degrees (i.e., Masters, PhD), medicine and allied health courses (e.g., physiotherapy, speech pathology, dietetics and podiatry) at undergraduate or graduate entry Masters levels. Prior to the redevelopment, creative problem-solving, inquiry/research and team work skills were developed to a lesser extent via the practical component of the subjects and there was noticeably less focus on writing and speaking skills, as well as student-led research projects. A goal of the redeveloped subjects was to better prepare students for careers in research or other health-related fields and this led to the design of assessment tasks that explicitly addressed the graduate attributes.

Therefore, as part of a university-wide curriculum renewal process, the Department restructured these subjects and introduced two semester-long final year capstone subjects, Advanced Physiology 1 and 2, in 2011. Consistent with recommendation six of the Design for Learning Project at La Trobe University, the aims of these subjects were to provide an effective culmination point for the Bachelor of Health Science course, as well as to offer students orientation to opportunities for further study, employment and career development. Specifically, the revised curriculum aimed to provide authentic research experiences for students studying advanced physiology and promote skill-development leading to work-readiness and/or entry to graduate studies in the Health and Biological Sciences.

This paper will provide an overview of the skills-related assessment and an evaluation of the success of the capstone program introduced in the Department, based on student performance and feedback scores in conjunction with coordinator and staff perceptions.

Methods

Context of the Study

The Department of Human Biosciences is positioned within the Faculty of Health Sciences and in 2011 the Faculty had a total enrolment of 8,439 students (25% of total institution enrolment). The new capstone program consisted of two semester-long final (third) year subjects: Advanced Physiology 1 (AP1; semester 1) and 2 (AP2; semester 2). These subjects were taken by Faculty of Health Sciences students majoring in anatomy and physiology (~40% of total enrolment) or as electives by Faculty of Science, Technology and Engineering students enrolled in biomedical science (~30% of total enrolment), nutrition or other science degrees (~30% of total enrolment). All students (~60% female) enrolled in AP1 (115 students in 2011) and AP2 (106 students in 2011) had completed two semesters of systems physiology at 2nd year (midpoint) level.

Ethical approval for this project was obtained from the Faculty of Health Sciences Human Ethics committee (reference FHEC 12/147 and 12/170).

Overview of Subject Organisation and Activities

Whilst physiology content remained an important aspect of the new capstone subjects, relevant and appropriate skills-related assessments were incorporated which were designed to address the goals of a capstone subject, as well as the graduate capabilities identified by our institution: writing, speaking, creative problem-solving, inquiry/research and team work.

Students attended four 1-hour lectures and one 3-hour laboratory class per week; a second 3-hour period was a 'guided independent learning block'. The content topics covered in these subjects were: principles of pathology and pharmacology, exercise physiology, central nervous system pharmacology and the musculoskeletal system (i.e., skeletal muscle, bone and connective tissue). Content knowledge was delivered in lectures and assessed via in-class team laboratory reports and an end of semester multiple choice exam. When comparing the new curriculum delivered in 2011 to that of earlier years, the content delivered was similar. In contrast, the assessment weighting for the final exam which was designed to assess material covered in lectures was changed. The exam weighting was decreased from 70% of the total grade in 2010 to 40% of the total grade in 2011. Prior to 2011, the 3-hour laboratory class was designed primarily to enhance understanding of the content. In contrast, the focus of the 2011 laboratory curriculum was to foster student-centred learning whereby students would develop research skills and team work skills. Prior to 2011, students could choose a different team each week, whereas in 2011 student teams of 5-6 students were established at the beginning of semester and the students remained in these teams for the entire semester. During the guided independent learning block, students continued to work on their skills-based assessment tasks and develop their research and team work skills.

Skills-Related Assessment

Curriculum changes were undertaken from a constructivist approach, promoting student-centred learning (Biggs & Tang 2011). The major difference between this capstone program and the previous curriculum is the inclusion of skills-related assessments throughout semester which are separate from content; all assessments were introduced for the first time in 2011. Learning outcomes were designed to address the development of research skills which included accessing and evaluating relevant literature, critical analysis and synthesis of published research, scientific writing, design and implementation of a research project, oral presentation and team work skills. Indeed, it has been well established that effective learning and conceptual change takes place when the intended learning outcomes are clear to both teachers and students (Biggs & Tang 2011). All of the skills-related assessment tasks were then aligned to the intended learning outcomes (Table 1). Teaching and learning experts in university education deem this practice essential for effective learning and conceptual change as it creates a teaching environment where students are required to engage in learning activities that are designed to achieve the intended learning outcomes (Biggs & Tang 2011). The chronological order of the assessment tasks was strategically devised such that the students would gain research skills in semester 1 (Fig. 1) that would assist them to design and conduct an independent research project in teams of 5-6 students over the entirety of semester 2 (Fig. 2). Students were provided with the intended learning outcomes, detailed assessment guidelines and marking schemes for all assessment tasks at the beginning of semester. All students were assigned an advisor for the literature review and independent project. Students were given opportunities to receive feedback on the literature review, experimental design and data analysis

for the independent project and for the journal article, oral presentation and poster prior to submission. For the journal article, students engaged in compulsory peer review of a fellow student's draft approximately 1 month prior to submission.

Table 1: Learning outcomes for skills-related assessments

	Skills-Related Intended Learning Outcome (ILO)	**Assessments**
1	Identify, access, and evaluate authoritative information	Online assignments
2	Critically analyse and synthesise published research in the field of physiology	Literature review
3	Interpret and present experimental findings in effective written form for a variety of audiences	Writing for the Public; independent research project journal article, poster and oral communication
4	Design and implement a research project and present this in effective written and oral form	Independent research project
5	Develop, maintain, and work as a member of a functional team	Peer review of team process; independent research project poster

The two physiology academics that were responsible for taking the lead in developing the new curriculum undertook extensive reading of the relevant literature and consulted on a regular basis with the La Trobe University Capstone expert in the Curriculum, Teaching and Learning Centre as well as Heads of School and Department, academics within the discipline, technical staff and other support staff. The consultation process occurred over a period of approximately two years as the new subjects were being developed and implemented. Eleven staff members from the Department of Human Biosciences, including the two subject coordinators, were directly involved in the delivery and assessment of the skills-related tasks in these capstone subjects in 2011. Teaching staff were prepared for the new assessment regime prior to implementation via a series of staff meetings, whereby the assessment tasks were presented in detail and discussed in relation to the constructivist theory of learning. As the implementation process unfolded, there were further staff meetings, as well as numerous informal conversations between the curriculum developers and teaching staff to ensure consistency in the approach to student-driven learning and skill development. Moderation of marks was undertaken for the literature review, journal article, team poster and writing for the public task (Fig. 1 and 2).

Figure 1: Overview of skills-related assessments in Advanced Physiology 1

Italics = team activity/assessment

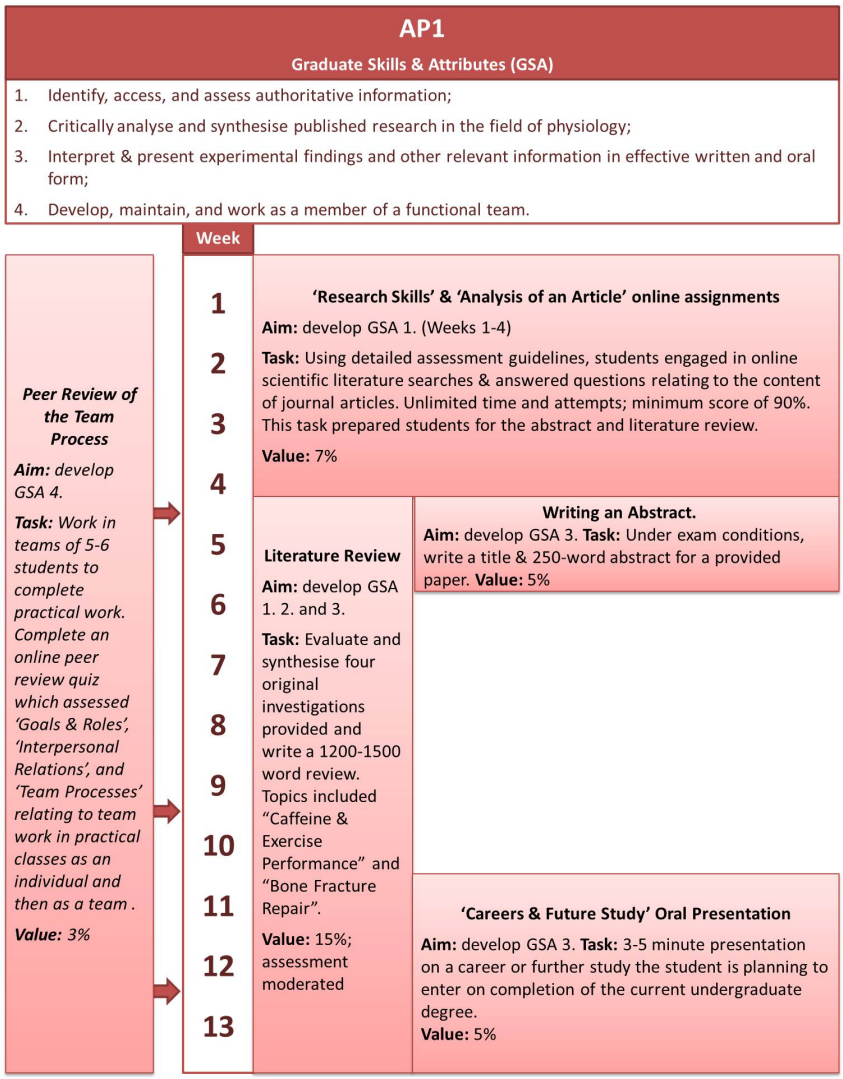
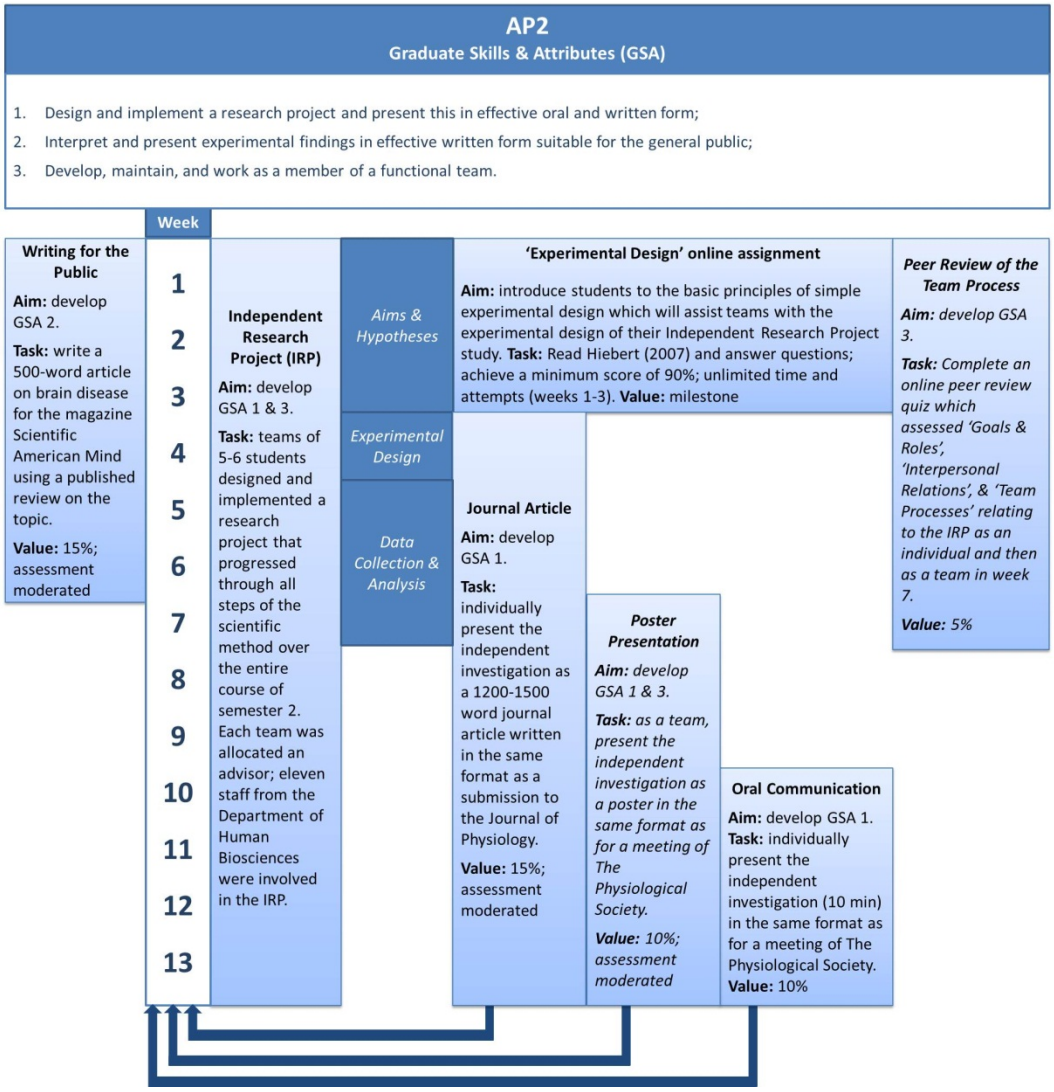


Figure 2: Overview of skills-related assessments in Advanced Physiology 2

Italics = team activity/assessment. Activities in solid-coloured boxes were not assessed but monitored by staff.



Evaluation of Capstone Subjects

Student performance

Student performance was assessed by marks allocated for skills-related assessment tasks, exam scores, final grades for each subject and the number of offers made for students to undertake Honours in the Department of Human Biosciences in 2012. Final grades for 2011 were compared with final grades awarded in 2010 and 2009. The students studying AP across the three years (2009-2011) were entirely different cohorts. One-way ANOVA tests were used to compare final grades for AP1 and AP2 from 2011, 2010 and 2009; post hoc Least Significant Differences (LSD) tests were used to determine which differences were significant. The percentage of students who received A (>79.49), B (>69.49), C (>59.49), D (>49.49) and N (<49.49) grades were also determined and presented graphically. Offers to apply to undertake Honours in Human Biosciences are sent to students with an average grade for AP1 and AP2 of 65% or above and the number of offers sent to students in 2011 was compared with those sent in 2010.

Student perceptions

Student opinions on learning, skill development, quality of the subject and overall student satisfaction were assessed via student feedback on the subjects. La Trobe University surveys were administered during the final weeks of semesters 1 and 2. The surveys comprised numerical items and an open-ended section which allowed students to provide additional comments. Students were given 15 minutes in practical class at the end of semester to complete the surveys anonymously and were instructed that completing the survey was optional. All surveys were collected and analysed by La Trobe University administration with summary reports returned to the coordinators after grades were finalised. Comparisons were made between results obtained in 2011 and those obtained in 2010 and 2009 before the subjects were capstones. Surveys were not conducted on AP1 in 2010. There were changes in the standard questions asked between 2011 and 2009 which reflected the emphasis on attainment of the graduate attributes identified by La Trobe University starting in 2010. As a result, the feedback obtained in more recent years provides better insight into how well the curriculum assisted students in gaining these important skills.

Staff and coordinator perceptions

Unsolicited verbal feedback was obtained from Department of Human Biosciences staff, both during and at the completion of each semester. Coordinators' perceptions were provided, from both student learning and logistical perspectives. Common observations and opinions that emerged from this informal feedback were summarised.

Findings

Student Performance

Student performance on the major skills-based assessment tasks in 2011 is presented in Table 2 along with final exam scores from 2011, 2010 and 2009. The students studying AP across the

three years (2009-2011) were entirely different cohorts. Final grades for AP1 (Fig. 3A) and AP2 (Fig. 3B) increased significantly in 2011 compared to 2010 and 2009 ($p < 0.01$). Post hoc LSD tests showed that the significant differences were between 2011 and 2010 ($p < 0.01$) and 2011 and 2009 ($p < 0.01$) for both AP1 and AP2 grades. The number of Honours offers sent out to students in 2011 (79%) was higher than in 2010 (35%).

Student Perceptions

Student responses to questions relating to learning, skill development, quality of the subject and to overall satisfaction are provided along with the response rates in Table 3. The mean results indicated that students found the subjects to be high in quality, relevant to their educational goals and that the subject content helped to improve their writing, speaking, research/inquiry, critical thinking, team work and problem-solving skills. Student feedback about themselves and their approach to learning in AP1 and AP2 are presented along with the response rates in Table 4. Students reported that they were interested in the material presented in both AP1 and AP2 and that they usually invested enough time and effort into their studies. For both feedback on the skills-related assessments and overall satisfaction and on student approaches to learning, the high levels of student satisfaction observed in 2009 and 2010 were maintained in 2011 with the introduction of the capstone elements in both subjects.

Table 2: Student performance on skills-related assessments and final exam

Assessment task	Minimum score (%)	Maximum score (%)	Mean score (%, ± SD)
Literature Review*	32	95	64 ± 9.6
Independent Research Project Oral Communication	60	100	80 ± 14.8
Independent Research Project Poster *	73	100	84 ± 10.9
Independent Research Project Journal Article *	26	93	70 ± 13.5
Writing for the Public *	53	100	71 ± 2.9
AP1 Final exam 2011 (n = 115)	31	90	60 ± 13.3
AP2 Final exam 2011 (n = 106)	31	90	61 ± 12.7
AP1 Final exam 2010 (n = 67)	31	86	58 ± 10.7
AP2 Final exam 2010 (n = 63)	21	86	57 ± 17.1
AP1 Final exam 2009 (n = 63)	32	86	59 ± 12.4
AP2 Final exam 2009 (n = 60)	28	82	56 ± 11.2

* Moderation of grades

Figure 3: Final grades for (A) Advanced Physiology 1 and (B) Advanced Physiology 2

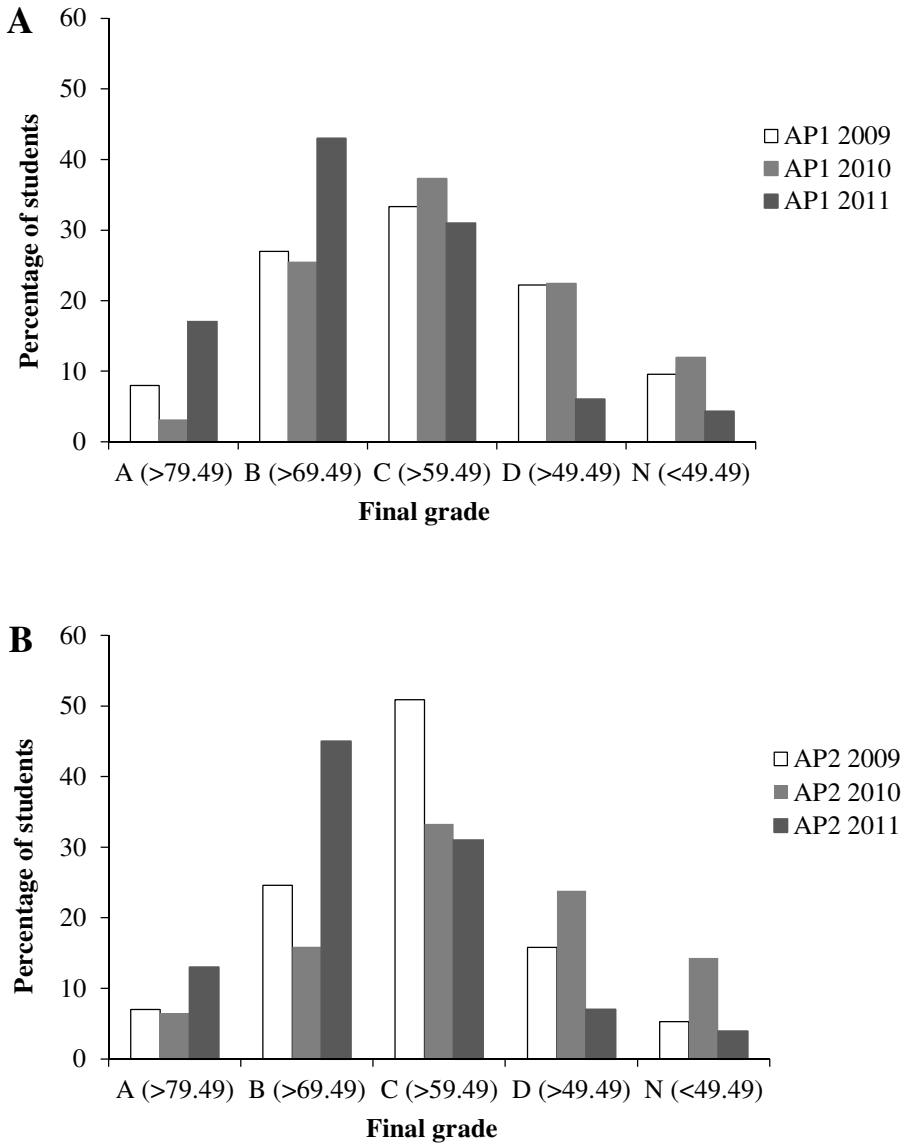


Table 3: Results of La Trobe University survey questions relating to the skills-related assessments and to overall satisfaction in AP1 and AP2

	Mean score (± SD)				
	2011		2010	2009	
Statement	**AP1**	**AP2**	**AP2**	**AP1**	**AP2**
I see the relevance of this subject to my to educational goals*	4.1 ± 0.8	4.2 ± 0.8	4.0 ± 0.8	4.1 ± 0.7	4.1 ± 0.9
This subject helps me to improve my writing skills*	3.7 ± 0.8	3.9 ± 0.9	3.7 ± 0.8	N/A	N/A
This subject helps me to improve my speaking skills*	3.5 ± 0.8	3.9 ± 0.9	3.2 ± 1.1	N/A	N/A
This subject helps me to improve my research/inquiry skills*	4.0 ± 0.9	4.2 ± 0.7	4.1 ± 0.8	N/A	N/A
This subject helps me to improve my critical thinking skills*	4.1 ± 0.8	4.1 ± 0.8	4.0 ± 0.8	N/A	N/A
This subject helps me to improve my team work skills*	4.3 ± 0.8	4.4 ± 0.7	4.0 ± 0.8	N/A	N/A
This subject helps me to improve my creative problem-solving skills*	3.9 ± 0.9	3.9 ± 0.8	N/A	N/A	N/A
Overall, the value of what I have learned in this subject is^	4.1 ± 0.8	4.0 ± 0.8	3.9 ± 0.8	4.1 ± 0.7	3.9 ± 0.7
Overall, the quality of this subject is^	4.0 ± 0.8	4.0 ± 0.7	4.0 ± 0.6	4.1 ± 0.6	3.9 ± 0.8
Response rate (%)	90.5	88.9	71.4	39.0	42.8

* 1 = never, 2 = rarely, 3 = sometimes, 4 = usually, and 5 = always.
^ 1 = very low, 2 = low, 3 = adequate, 4 = high, and 5 = very high.
N/A = questions not asked in this survey

Table 4: Results of La Trobe University survey questions relating to student approaches to learning in AP1 and AP2

	Mean score (± SD)				
	2011		2010	2009	
Statement	**AP1**	**AP2**	**AP2**	**AP1**	**AP2**
I am interested in learning about this subject material*	4.2 ± 0.6	4.2 ± 0.6	4.2 ± 0.6	4.2 ± 0.6	4.1 ± 0.7
I invest enough time and effort to meet/exceed subject requirements*	3.9 ± 0.8	3.8 ± 0.8	4.0 ± 0.6	4.0 ± 0.7	3.9 ± 1.0
Overall, I give my best possible effort to learning in this subject*	4.0 ± 0.6	4.0 ± 0.7	4.0 ± 0.6	4.2 ± 0.8	4.0 ± 0.6
Response rate (%)	90.5	88.9	71.4	39.0	42.8

* 1 = never, 2 = rarely, 3 = sometimes, 4 = usually, and 5 = always.

Staff and Coordinator Perceptions

The two physiology academics who were responsible for the development and implementation of the capstone program acted as the subject coordinators for AP1 and AP2 in 2011 and also participated as advisors for the skills-related assessments.

Unsolicited feedback from staff involved in teaching into AP1 and AP2 in 2011 reflected that they felt students were much more engaged and independent; students seemed proud of their work on the independent research project, particularly when presenting their team posters; they enjoyed acting as advisors in the independent research project; and they thought that the students were better prepared to undertake Honours after completion of AP1 and AP2.

The foremost perception of the coordinators was that there was a vastly increased workload associated with coordinating AP1 and AP2 in 2011 compared to 2010 (different staff acted as coordinators in 2009). There was a greater need for infrastructure services (e.g., library, computer laboratories, online learning management system and presentation spaces with adequate audio-visual capabilities) and support staff (e.g., librarians, laboratory staff and IT staff) to run these subjects in 2011. Consistent with staff perceptions, coordinators observed that students were very engaged throughout semester 1 and 2, particularly by the independent research project during which they demonstrated an autonomous self-directed learning approach.

Discussion

Many Australian and international universities have considered the need to provide students with a culminating academic experience that brings together the knowledge of an academic discipline and student transition to the world of work (Holdsworth, Watty & Davies 2009). The aim of this paper was to provide an overview of the assessment tasks of the capstone program and to evaluate the success of the implementation of the capstone program. In our opinion, impressive student marks and grades were obtained for both subjects, based on rigorous assessment criteria, and this reflects a high level of performance in scientific writing, oral presentation, team work and research skills. Student feedback also indicated that there was a high level of student learning and skill development. Finally, both the teaching and coordination staff thought that the outcome of the newly introduced curriculum was a significant increase in the degree of student-centred learning, along with the development of research skills and graduate capabilities.

Student Performance

Student marks for the newly introduced skills-related assessment in 2011 reflect a high level of performance. Although this data cannot be compared to previous years, the authors thought that it was important to present the average marks for the skills-related assessments to indicate student outcomes for the newly introduced curriculum. The average marks for the online research skills assignments, poster presentation and independent project oral presentation were at A standard (80-100%), the journal article and writing for the public article were at B standard (70-79.49%) and

the literature review was at C standard (60-69.49%). The main goal of the skills-related assessments was to facilitate learning through participation in authentic experiences and a secondary goal was to provide certification of achievement. Boud and Falchikov (2006) indicate that long term learning occurs through participation, rather than acquisition, and learning after University in work and life settings is highly embedded in a particular context. The independent research project was an ideal context to foster authentic, student-centred learning where students were given autonomy and control over the choice of subject matter, the pace of learning and the learning methods used. In this regard, the term 'advisor' was a very deliberate choice over that of 'supervisor'. The high student marks for the skills-related assessments may be explained by the prominent degree of student engagement, the transparency of assessment, the strategic chronological placement of assessments, the appropriate complexity of tasks relative to the time allocated and the appropriate amount of input from staff. Indeed, Felder and Brent (1996) reported student concern regarding educators achieving a balance between a method that was too teacher-driven at one extreme and excessively student-centred on the other. Moreover students perceived conventional didactic approaches of teaching to be less motivating and less effective; however, they were anxious about a teaching style that lacked structure, guidance and support (Felder & Brent 1996). We propose that the advisor to student ratio of approximately 1:12 for the literature review and independent project was ideal, as it ensured that staff had the time to develop a rapport with students and provide advice on experimental design, data collection and data analysis, as well as feedback on written drafts. In support of our staff to student ratio, FitzPatrick (2004) reported that in her capstone subject the development of a structure consistent with several student groups, with each performing completely different experiments, could create a difficult situation for the facilitator that required a high level of vigilance, adaptability and quick thinking.

Overall, the learning of physiology content has remained relatively stable over the 2009-2011 period as the number and type of lectures delivered and student results in the final exam were similar. Therefore, we propose that the increased AP1 and AP2 grades reflect an increased development of research skills and graduate attributes.

Student and Staff Perceptions

Student feedback in the 2011 university surveys indicated that students were of the opinion that the skills-based assessments contributed to their learning experience and skills development. Furthermore, students believed that the subjects were of a high quality and reported a high level of satisfaction with the capstone program. This observation is supported by Robbins, Kinney and Kart (2008) who reported that students' perceptions of their own research skills were enhanced after completion of a health sciences capstone subject. Furthermore, prior to 2011 students typically provided very positive feedback on the more traditional advanced physiology subjects. Therefore, a high level of student satisfaction was maintained in 2011 despite increased demands placed on the student, such as more team work, more challenging assessment tasks, a greater requirement to implement time management and organisational skills and a requirement to work consistently throughout the semester. Response rates to student surveys increased in 2010 and 2011 due to a change in procedure in which surveys were conducted during practical classes instead of lectures which were not as highly attended. Therefore, results are more likely to reflect the opinions of the majority of the cohorts rather than those who regularly attended lectures. We believe that the emphasis on improvement of research and communication skills in the new

curriculum is reflected in the positive student responses to survey items relating to writing, speaking, research/inquiry, critical thinking and creative problem-solving skills. Similarly, the enhanced role of the team in practical work and in the independent research project was reflected in high scores relating to improvement of team work skills.

Staff perceptions were that the skills-related assessments included in the 2011 curriculum better prepared students for Honours, graduate studies and employment by improving their general understanding of the scientific method, enhancing their ability to access reliable and relevant literature and improving their ability to write a literature review and journal article, conduct data analysis and give an oral presentation. Staff were also of the opinion that the role of advisor in the capstone subjects was a more enjoyable way to teach when compared with the more teacher-driven didactic approach. These findings are supported by FitzPatrick (2004) who reported that working with students as scientific collaborators was a more creative and rewarding way to teach. It was evident that students were particularly proud of their independent research projects and there was a noticeable increase in student engagement and independent learning. This observation is also supported by FitzPatrick (2004) who reported that student-driven learning provided students with a sense of ownership over their work. Indeed, it has been clearly established in teaching and learning practice that students can easily abdicate responsibility for their own behaviour if they are not in charge (Svinicki 1998). When students are able to make decisions for themselves they are more likely to take ownership, succeed and experience affirmation of their self-worth (Svinicki 1998).

Staffing and Resources Consideration

Despite the obvious benefits of the new curriculum to student learning in advanced physiology subjects, the implementation and coordination of the capstone subjects required a greater amount of effort than subjects taught using a more didactic approach. The design phase of the capstone program required an equivalent of 1 full time staff member for 1 year. The design and implementation of capstone subjects was incredibly time-consuming because it required deliberate planning of assessment tasks that would allow sequential development of skills that addressed all graduate capabilities in authentic ways. Online assignments required creative use of the online learning management system (LMS) to allow students to act more independently and to obtain information in a self-paced manner. Detailed and clear assessment guidelines and marking schemes were written for all assessment tasks. Following the initial design and implementation phase, ongoing support from academic department staff is essential due to the high workload associated with advising students as they, for example, write literature reviews and undertake the independent research project as well as completing the marking required for the assessment tasks. Having more staff involved in the subjects was beneficial in sharing the workload and allowed for better student to staff ratios for providing feedback and marking. Another benefit of this is the collegial atmosphere created by having many staff working towards the common goal of providing a capstone experience rather than the more traditional scenario in which staff teach into their topic areas in more discrete blocks. It is important to note that when many staff are involved, it is imperative that everyone is made aware that student-centred learning is a major principle underlying the capstone experience; this can be challenging for some staff and clear guidance by the coordinators is important.

In agreement with Felder and Brent (1996), it also became apparent during the planning and implementation of the new curriculum that student-centred learning was highly dependent on University infrastructure services and support staff. Implementation of the independent research project relied heavily on well-trained laboratory/technical staff and availability of laboratory space (both inside and outside of timetabled class time) and a wide range of equipment to enable students to design imaginative experiments. Introduction of online assignments required inventive use of the LMS and assistance from IT staff for trouble-shooting. It would be ideal to have knowledgeable IT staff available to assist with the initial design and setup of LMS sites to ensure that the full potential of this technology is realised. Support from the library is essential for assessments related to research skills; staffing limitations meant that the library was not able to offer as much practical support as they wished which therefore increased the burden on coordinators. Also, small teaching spaces equipped with lecture facilities (computers, projectors) were difficult to find for concurrent oral presentation sessions and these types of rooms are essential for providing authentic learning opportunities.

Therefore, it would be wise for universities and departments to take staff and resource requirements into account when implementing curriculum that has a truly a student-centred approach.

Conclusion

In summary, consistent with the Design for Learning Project (http://www.latrobe.edu.au/ctlc/dfl/), a variety of assessment tasks designed to enhance the development of research skills and graduate capabilities were introduced in 2011 for the new 3rd year physiology capstone subjects. Student marks and grades for both subjects, which were determined using rigorous assessment criteria, reflect a high level of performance in scientific writing, oral presentation, team work and research skills. Student feedback also indicated that there was a high level of student learning and skill development. Taken together, our findings are in support of others that indicate that well-designed capstone subjects foster the development of a range of research skills (Shoaf 2000). Therefore, the newly implemented advanced physiology capstone curriculum includes activities and assessments that provide an effective culmination point for the Bachelor of Health Science course, better preparing students for postgraduate study and employment than curriculum focusing purely on learning physiology content.

Reference List

Anderson, TF & Elloumi, F (eds) 2004, *Theory and Practice of Online Learning*, Athabasca University, Athabasca, Canada.

Blake, C 2010, *Careers for Science Graduates*, Graduate Careers Australia, Melbourne, accessed 7/12/2012, http://www.graduatecareers.com.au/wp-content/uploads/2011/12/careers_for_science_graduates.pdf

Biggs, J & Tang, C 2011, *Teaching for Quality Learning at University*, Open University Press, accessed 4/12/2012, La Trobe University Library.

Boud, D & Falchikov, N 2006, 'Aligning assessment with long-term learning', *Assessment & Evaluation in Higher Education*, vol.31, no.4, pp.399-413.

Felder, RM & Brent, R 1996, 'Navigating the bumpy road to student-centred instruction', *College Teaching*, vol.44, no.2, pp.43-47.

FitzPatrick, KA 2004, 'An investigative laboratory course in human physiology using technology and collaborative writing', *Advances in Physiology Education*, vol.28, pp.112-119.

Gibbs, G 1992, *Assessing More Students*, Oxford Brookes University, Oxford.

Hiebert, SM 2007, 'Teaching simple experimental design to undergraduates: do your students understand the basics?', *Advances in Physiology Education*, vol.31, pp.82-92.

Holdsworth, A, Watty, K & Davies, M 2009, 'Developing capstone experiences', *Centre for the Study of Higher Education*, The University of Melbourne.

Robbins, EJ, Kinney, JM & Kart, CS 2008, 'Promoting active engagement in health research: lessons from an undergraduate gerontology capstone course', *Gerontology & Geriatrics Education*, vol.29, pp.105-123.

Shoaf, MM 2000, 'Classroom Note: A capstone course for pre-service secondary Mathematics teachers', *International Journal of Mathematical Education in Science and Technology*, vol.31, no.1, pp.151-160.

Svinicki, MD 1998, 'Motivating students to learn', in KA Feldman & MB Paulsen (eds), *Teaching and learning in the college classroom*, Simon & Schuster Custom Pub, Needham Heights, MA, pp.508-527.

Weimer, M 2002, *Learner-Centred Teaching: Five Key Changes to Practice*, Jossey-Bass, San Francisco.